03-20-00

A

Date of Deposit: March 17, 2000

Express Mail # EK 108 993 971 US

I hereby certify that this is being deposited with the United States Postal Service "Express Mail, Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed **to Box PATENT APPLICATION**, Asst. Commissioner for Patents , Washington, D C 20231

By: Elmer Galbi

Elmer Galbi, Reg. No. 19,761
13314 Vermeer Drive
Lake Oswego, OR, 97035
Telephone 503-697-78444

Commissioner of Patents and Trademarks
Washington, D.C. 20231

Dear Sir:

Transmitted herewith for filing is the following new patent application:

Inventors: **Geoffrey Rhoads**, whose address is **304 S.W. Tualatin Loop, West Linn, OR 97068**
Adnam M. Alattar whose address is **25 NE Tandem Way Apt#188, Hillsboro, OR 97124**
& Ravi K. Sharma whose address is **2557 NW Overlook Dr. #536, Hillsboro, OR 97124**

Title: **Pre-filtering to Increase Watermark Signal-to-noise Ratio**

Attorney Docket Reference: **EWG-091-US**

Enclosed are:

1) **A specification of the invention including two (2) sheets of drawings**
2) **An un-signed Declaration by the Inventors**
3) **A return addressed postcard for filing notification**

Please charge the filing fee and any other applicable fees during the pendency of this application (or credit any overpayment) to Deposit account 501071 which is in the name of Digimarc Corp. (A duplicate copy of this sheet is enclosed)

Please direct all correspondence to:

Elmer Galbi, Esq.
13314 Vermeer Drive
Lake Oswego, OR 97035
Phone 503-697-7844

Respectfully submitted,

Elmer Galbi

Elmer W. Galbi, Reg. No. 19,761
13314 Vermeer Drive
Lake Oswego, OR 97035

Direct phone calls to: (503) 697-7844

Pre-filtering to Increase Watermark Signal-to-noise Ratio

Relaterd Applications:

Priority is claimed to co-pending application 60/125,349 filed 3/19/99 and to co-pending application 09/503,881 filed February 14, 2000.

Field of the Invention:

The present invention relates to steganography and more particularly to detecting digital watermarks.

Background of the Invention:

Techniques for embedding a hidden digital message (i.e. a digital watermark) in a host medium such as an image, audio or video are well known. Various known watermarking applications verify the presence of the watermark in a target image, audio or video medium. There are also various known techniques for detecting and extracting (i.e. reading) digital watermark signals. Many watermarking applications are based on the ability of some types of watermark signals to survive manipulations (e.g. rotation, scaling and digital/analog conversions) which tend to weaken watermark signals.

Summary of the Invention:

The present invention utilizes pre-processing (pre-filtering) of the target data in order to facilitate and enable robust extraction of a watermark signal. With the present invention the watermarked data is pre-filtered using knowledge of the watermark signal. That is, utilizing knowledge of the characteristics of the watermark signal (for example that it falls in a certain frequency range), aspects or portions of the signal that do not carry the

watermark signal are eliminated by filtering. Such filtering can amplify the watermark signal and/or simultaneously reduces the strength of the original (host) content or noise in the data signal that contains the watermark. That is, pre-filtering increases the signal-to-noise ratio of the watermark signal and facilitates the watermark extraction steps (detection and decoding). With the present invention it is possible to extract weak watermark signals from target data.

Brief Description of the Figures:

Figure 1 is a diagram illustrating the prior art.

Figure 2 is a diagram illustrating the present invention.

Detailed Description:

A prior art watermark detection system is illustrated in Figure 1. Target data 10 which can be in the form of a watermarked image, a watermarked audio signal, or a watermarked video signal is operated on by a watermark detection and extraction device 11. Watermark detection devices generally use knowledge of the watermark signal 12 in order to detect and read or decode the watermark signal. The watermark detection device 11 can be a special purpose device, an appropriately programmed computer or a computer subroutine which is part of a larger program or device. Watermark detection and reading programs are known and commercially available.

A preferred embodiment of the present invention is illustrated in Figure 2. The input is similar to that shown in Figure 1. That is the input can be a watermarked image, watermarked audio data, or watermarked video data. The data is first passed through a

filter 21 which utilizes knowledge of the watermark to filter out aspects or portions of the target data that do not contain watermark information of interest.

The following description, pertains to a situation where the host medium is an image. The host image contains a conventional digital watermark that has specific frequency characteristics (while the following discussion relates to an image which is carrying watermark data, the invention is equally applicable to audio or video data that is carrying watermark data). As is conventional the watermark signal has been repeatedly embedded in several regions of the host image. Consider an image that is divided into regions of n by m pixels. The task of watermark extraction is to first identify and isolate the frequencies of interest. This is achieved by correlating the power spectrum of the target image with the power spectrum of the watermark signal. As is well known, the host image content and the manipulation applied to the watermarked image introduce noise in the correlation process.

With the present invention, the image data in each block is pre-filtered using a nonlinear filter 21 prior to watermark extraction by conventional units 11 and 12. The nonlinear pre-filter consists of two steps. The first step consists of applying a highpass filter (e.g. Laplacian operator) to each region. The highpass filter computes a new intensity value at each pixel in the image using

Filtered intensity = Old intensity – average intensity of the 8 neighbors of the pixel

The second step consists of applying a nonlinear operator (e.g. signum function) to the filtered output of the highpass filter. Each pixel is now modified as

New intensity = 1 if (Filtered intensity > 0)

= 0 if (Filtered intensity = 0)

= -1 if (Filtered intensity < 0)

The highpass filter attenuates the low frequencies and amplifies the contribution from the higher frequencies in each region. The contribution to the low frequencies is mostly from the host image content. Higher frequencies from the watermark signal are amplified. The nonlinear operation whitens the noise caused by the host image content in the frequency domain, increasing the signal-to-noise ratio of the watermark signal. Following the non-linear pre-filter, the power spectrum of several regions is added together. Since the watermark frequencies repeat through several regions, the power at those frequencies adds up. The image frequencies from region to region are generally non-repetitive and get averaged out. The resulting power spectrum contains a higher signal-to-noise ratio watermark signal, and is then correlated with the power spectrum of the watermark.

The filter is a combination of a Laplacian filter followed by a non-linear operation that limits the output of the Laplacian filter to be –1, 0, and +1. This filter is very effective in detecting the watermark signal.

In summary, the present invention can operate on any type of watermarked signal include watermarked images, watermarked audio signals and watermarked video signals. By knowing the characteristics of the watermark (for example that it falls within a certain frequency range) filtering can be used to reduce the portions of the signal that

are less likely to contain the watermark signal. The LaPlacian and Signum filters used in the above embodiment of the invention are specific examples of filters that can be used; however, many other types of filters can b e used in various embodiments of the invention without departing from the sprit and scope of the invention.

It will be understood by those skilled in the art that the technique of reducing or removing portions of the signal in certain frequency ranges can be applied to frequency domain watermarking methods (methods that encode auxiliary data by altering transform coefficients) in order to enhance watermark detection and reading.

By way of summary (without limiting the breath of the forgoing) this invention facilitates robust watermark extraction by applying a pre-filter that utilizes knowledge about the watermark signal. Such knowledge may include characteristics of the watermark such as specific frequencies, locations in the host medium (spatial and/or temporal) or specific properties of the host image that help locate and extract the watermark.

The entire specification of co-pending application 09/503,881 filed February 14, 2000 and assigned tot he assignee of the present invention is hereby incorporated herein in its entirety by reference.

While the invention has been described with respect to various preferred embodiments thereof, it should be understood that various changes in form and detail may be made without departing from the spirit and scope of the invention.

I claim:

1) A system for detecting a watermark in host data which includes:

a watermark detection mechanism which utilizes knowledge of the characteristics of a watermark to detect the present of a watermark, and

a filter which removes aspects of the host data that are not carrying watermark data, thereby enhancing the signal to noise ratios of the watermark signal.

2) The system recited in claim 1 where the host data is image data.

3) The system recited in claim 1 where the host data is audio data.

4) The system recited in claim 1 where the host data is video data.

5) The method of extracting digital watermark data from host data which includes, pre-filtering said host data prior to the watermark detection operation thereby enhancing the signal to noise ratios of the watermark signal.

6) The method recited in claim 5 wherein said pre-filtering consists of first applying a highpass operator to said host data and then applying a nonlinear operator to said data.

7) The method of claim 5 wherein the host data is image data.

8) The method of claim 5 wherein the host data is audio data.

9) The method of claim 5 wherein the host data is video data.

10) The method of claim 6 wherein said highpass operator is a Laplacian operator.

11) The method of claim 6 wherein said nonlinear operator is a Signum operator.

12) The method of detecting a watermark signal in host data which includes, first filtering said host data using a high pass Laplacian filter, applying a nonlinear signum function to the output of said high pass filter, and then detecting the presence of a watermark signal in said filtered data.

Abstract:

Utilizes pre-processing (pre-filtering) of target data in order to facilitate and enable robust extraction of a watermark signal. With the present invention the watermarked data is pre-filtered using knowledge of the watermark signal. That is, utilizing knowledge of the characteristics of the watermark signal (for example that it falls in a certain frequency range), aspects or portions of the signal that do not carry the watermark signal are eliminated by filtering. Such filtering can amplify the watermark signal and/or simultaneously reduces the strength of the original (host) content or noise in the data signal that contains the watermark. That is, pre-filtering increases the signal-to-noise ratio of the watermark signal and facilitates the watermark extraction steps (detection and decoding). With the present invention it is possible to extract weak watermark signals from target data.

Figure 1 (Prior Art)

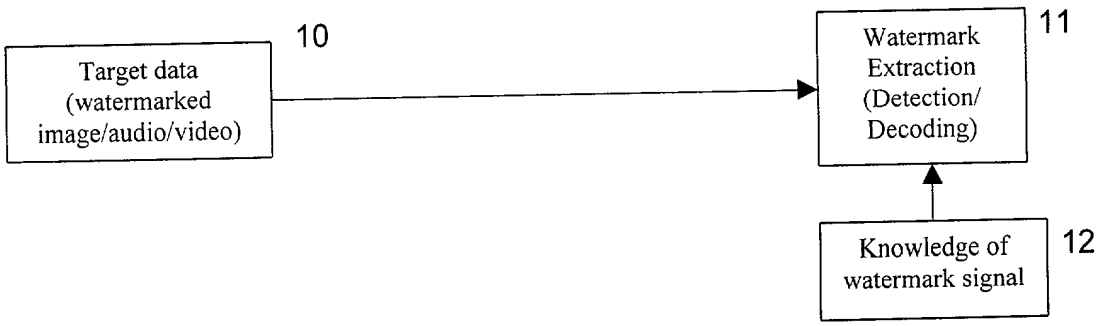
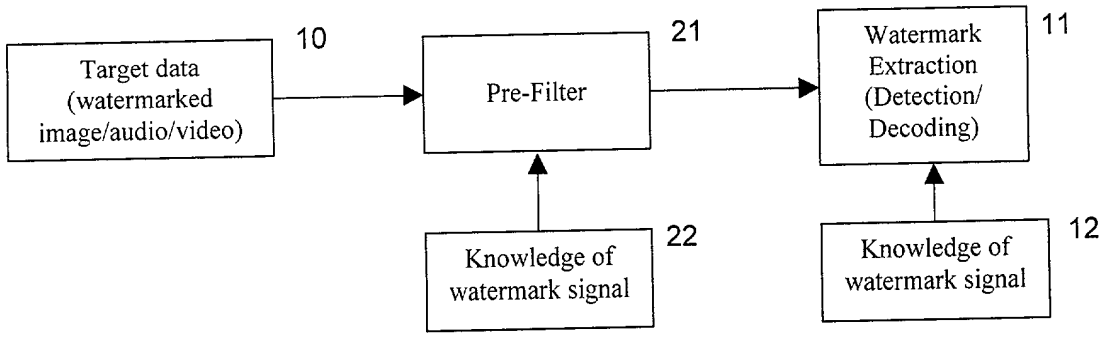


Figure 2


Target data (watermarked image/audio/video)
10
Pre-Filter
21
Watermark Extraction (Detection/ Decoding)
11
Knowledge of watermark signal
22
Knowledge of watermark signal
12

DECLARATION BY INVENTORS

Each of the below named inventors, hereby declares that:

My residence, post office address and citizenship are as stated below next to my name,

I believe that I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention,

Entitled: **Pre-filtering to Increase Watermark Signal to Noise Ratio**
Docket Number: **EWG-091 US,**
the specification of which is attached hereto.

I hereby state that I have reviewed and understand the contents of the above identified specifications, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations 1.56(a).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made, with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

CLAIM OF PRIORITY BASED ON FOREIGN APPLICATIONS **NONE**

CLAIM OF PRIORITY BASED ON PREVIOUSLY FILED U.S. APPLICATIONS:
Application Serial Number 60/125,349 filed March 19, 1999 which is now pending.
Application Serial Number 09/503,881 filed February 14, 2000 which is now pending.

Geoffrey Rhoads **USA** _____
Inventor name Citizenship Signature Date

304 S.W. Tualatin Loop, West Linn, OR 97068
Post Office Address and Residence

Adnam M. Alattar _____
Inventor name Citizenship Signature Date

25 NE Tandem Way Apt#188, Hillsboro, OR 97124
Post Office Address and Residence

Ravi K. Sharma **India** _____
Inventor name Citizenship Signature Date

2557 NW Overlook Dr. #536, Hillsboro, OR 97124
Post Office Address and Residence